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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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Spacing, Thinning, and Pruning Practices for Young Cottonwood Plantations

ABSTRACT. — The 5-year growth of cottonwood trees planted at five spacing levels is summarized. Wide spacing resulted in better diameter and height growth, but less total wood production per acre than close spacing. Early thinning of closely spaced trees did not maintain diameter growth equal to that of trees with initial wide spacing.

OXFORD: 238:232.43:242:245.1:176.1 *Populus deltoides*

Eastern cottonwood (*Populus deltoides* L.) can be grown on alluvial soils at exceptionally short rotations for various wood products or for stabilization of river and stream front sites. Successful plantations require intensive practices for planting and culture.[1,2] Because more information is needed on intensive management of cottonwood, the effects of spacing, thinning and pruning practices were compared in young plantations. Results after 5 years show that: (1) initial spacing strongly affects subsequent growth, (2) early thinning cannot overcome the effects of narrow initial spacing, (3) method of thinning affects growth, and (4) early pruning is required for clear bole length.

METHODS

In the spring of 1963 three plantings of cottonwood of about 5 acres each were established on alluvial secondary bottoms in southern Illinois. Sites were nearly flat and soil types were mostly Belknap, Sharon, and Cuba. Some small strips of Bonnie soil were also present. Planting sites received complete site preparation and plantations were established with seedlings and given intensive care including cultivation, fertilization, and spraying for insects.[2]

Five initial spacings were tested on 1-acre plots in three different areas: 25, 50, 100, 200, and 400 square feet per tree, essentially equivalent to 5- by 5-, 7- by 7-, 10- by 10-, 14- by 14-, and 20- by 20-foot spacings (table 1). Each spacing plot was divided into three parts to test the effect of thinning, and these parts were split to compare two pruning treatments. One part was mechanically thinned, one part was free-thinned, and one part was left untreated. In mechanical thinnings alternate rows were removed; one direction in the first thinning and at right angles in the second thinning. Each thinning removed half the trees present. Free thinnings also removed half the trees but "leave" trees were selected on the basis of quality rather than spacing. Although the pruning treatment will ultimately remove all branches to a height of 25 feet or more, only dead branches were pruned in the first 5 years. The original objective in thinning was to maintain about equal diameter growth in all spacing treatments. The two wide-spaced plots were not thinned because diameter growth had not yet slowed down.

Trees were pruned at all spacings at the end of the fourth and fifth years.

RESULTS

After 5 years, survival in the unthinned plots and subplots was 95 percent for the two wide spacings, 86 percent for the 10-foot spacing, and 77 percent for the two narrow spacings. A few trees were replanted in the two wide-spaced plots. Stocking was uniform and in accordance with the treatments (table 1).

[1] *McKnight, J. S. and Biesterfeldt, R. C. Commercial cottonwood planting in the southern United States. J. Forest. 66(9): 670-675. 1969.*

[2] *Minckler, L. S., and Woerheide, John D. One way to establish cottonwood plantations — a case history. South. Lumberman 211(2632): 177-178, illus. 1965.*

Table 1. — *Number of live cottonwood trees per acre at the end of the fifth year (mean of three replications)*

Original spacing (feet)	Number originally planted	Number of thinnings[1/]	Thinning treatment: Mechanical	Free	None
5 by 5	1,742	2[2/]	341	350	1,319
7 by 7	871	2[2/]	162	161	660
10 by 10	436	1[3/]	189	189	378
14 by 14	218	0	209	210	210
20 by 20	109	0	105	106	106

1/ Half the trees removed at each thinning.
2/ End of third and fourth years.
3/ End of fourth year.

Plantation Development

Through the second year, mean tree diameter of unthinned stands was not affected by spacing. From the third through the fifth year, however, there were increasing differences in diameter related to spacing up to 14 feet. At the end of the fifth year, trees in the 14- and 20-foot spacings had similar mean tree diameters (table 2).

Table 2. — *Height, diameter, and basal area of trees in cottonwood plantations 5 years after planting (mean of three replications)*

Original spacing (feet)	Number of thinnings	Thinning treatment: Mechanical	Free	None
		MEAN HEIGHT		
		Ft.	Ft.	Ft.
5 by 5	2	33	33	29
7 by 7	2	33	36	37
10 by 10	1	34	36	36
14 by 14	0	41	38	39
20 by 20	0	38	36	35
		MEAN D.b.h.		
		In.	In.	In.
5 by 5	2	3.7	3.9	2.9
7 by 7	2	4.1	4.7	4.1
10 by 10	1	4.6	5.0	4.8
14 by 14	0	6.1	5.5	5.6
20 by 20	0	6.3	5.7	5.7
		BASAL AREA PER ACRE		
		Sq.ft.	Sq.ft.	Sq.ft.
5 by 5	2	28	31	69
7 by 7	2	16	20	64
10 by 10	1	23	26	50
14 by 14	0	43	36	38
20 by 20	0	24	20	20

Annual height growth averaged over 7 feet and did not vary greatly from year to year. Trees spaced 5- by 5-feet apart began to slow down in height growth at the end of 3 years but height growth remained rather uniform at all other spacings. In unthinned, wide-spaced plantations, the average tree was 38 feet tall and 5.8 inches d.b.h. at the end of 5 years (fig. 1). In the 5-foot spacings the average tree was 32 feet tall and 3.5 inches d.b.h. (fig. 2). Average heights and diameters of trees in the other spacings ranged between these sizes (table 2).

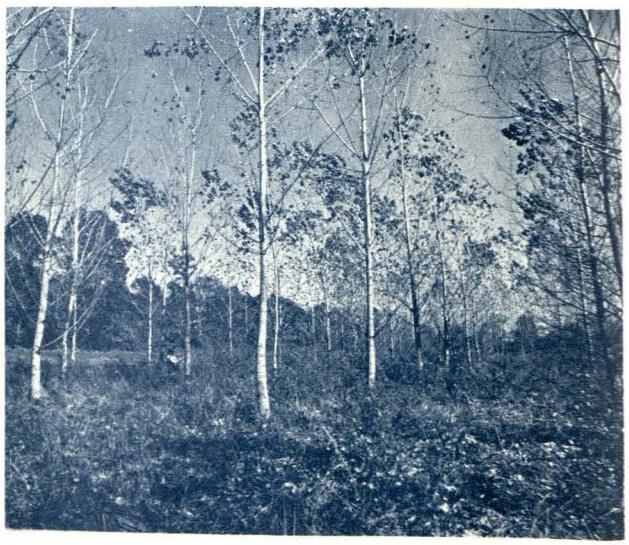

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Figure 1. — Cottonwood plantation spaced 20 by 20 feet at start of the sixth growing season. Dead limbs have been pruned from trees in the center foreground.

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Figure 2. — Cottonwood plantation spaced 5 by 5 feet at start of sixth growing season.

At 5 years, basal area of unthinned stands ranged from 69 square feet per acre for 5-foot spacing to 20 square feet for 20-foot spacing (table 2). Total basal area of the stand was related to number of trees per acre (table 1) but obviously not in a linear fashion. For example, the unthinned 5 by 5 plantations had 12 times as many trees but only 3½ times as much basal area as the 20 by 20 stands.

The differences among treatments became sharply apparent during the fifth year. Mean height growth in the fifth year was two to three times as much for 20 by 20 plantations as it was for 5 by 5 plantations, whether thinned or not. Other spacings were intermediate. Tree diameter growth in the fifth year for unthinned stands was closely related to original spacing; trees in the 20 by 20 plots grew more than three times as much as those in the 5 by 5 stands (table 3). During the fifth year the differences in basal area

Table 3. — *Mean diameter growth of cottonwood trees during the fifth year*
(Inches d.b.h.)

Original spacing (feet)	Number of thinnings	Thinning treatment		
		Mechanical	Free	None
5 by 5	2	0.65	0.97	0.39
7 by 7	2	.62	1.31	.56
10 by 10	1	.86	1.18	.87
14 by 14	0	1.19	1.16	1.10
20 by 20	0	1.39	1.33	1.26

growth of unthinned stands were diminishing, but original spacing still influenced growth. The stands spaced 5 by 5, 7 by 7, and 10 by 10 grew 16 to 17 square feet per acre, the 14 by 14 stands grew nearly 14 square feet, and the 20 by 20 plots grew about 8 square feet.

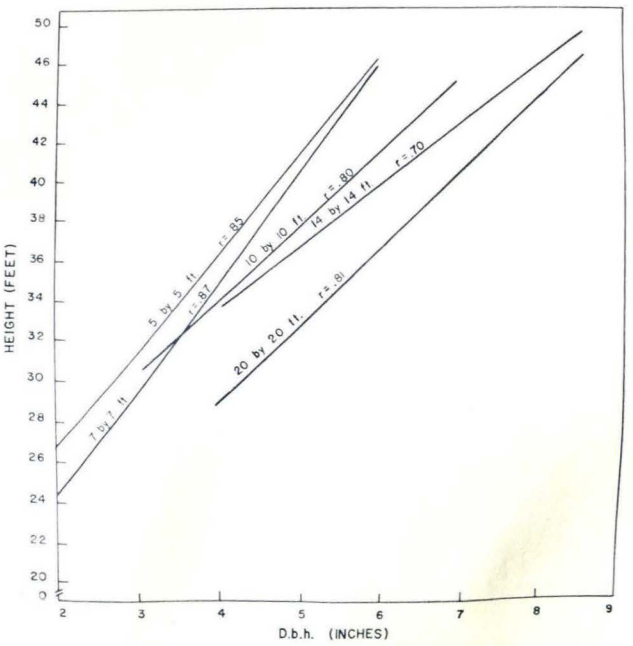
Effect of Thinning

After 5 years, mean tree diameter in heavily thinned plantations was only about 60 to 70 percent that of trees in plantations with original wide spacing (table 2). However, diameter growth in free-thinned plots during the fifth year was about equal to that of originally wide-spaced plots and much greater than for mechanically thinned plots (table 3). Mechanical thinning did not increase total diameter or fifth-year diameter growth except in the 5 by 5 spacings.

Height-Diameter Relation Affected by Spacing

Even though stand density did not greatly affect mean height, it did change the relationship between height and diameter (fig. 3). The wider the spacing the greater the d.b.h. in relation to height. For example, 38-foot trees in 5 by 5 plots were less than 4.5 inches d.b.h., whereas in 20 by 20 plots they were more than 6.0 inches d.b.h.

Figure 3. — Regression of height over d.b.h. at age 5 for unthinned stands of different spacings.



Pruning Dead Branches

Clear length for pruned trees ranged from 17 feet for 5 by 5 spacing to about 5 feet for 20 by 20 spacing. The clear bole length for thinned plantations was about 2 or 3 feet less than for unthinned. Unpruned plantations had only about 2 feet of clear length, and this did not vary among spacings.

Pruning time per tree averaged 3.7 man-minutes the fourth year and 2.1 man-minutes the fifth year. There was little difference in pruning time per tree among spacings or between thinned and unthinned plots. Wider spaced trees had fewer but larger limbs to prune.

CONCLUSIONS

Appropriate planting methods, intensive early care, and suitable sites are essential for establishment of successful cottonwood plantations. If these are not provided, it is useless to plant cottonwood. The spacing, thinning, and pruning practices that should be used depend on the objectives of management. Spacing also affects costs of establishment and subsequent care, especially where machinery is used.

Early results of this study strongly suggest that wide spacings will be best for large products or combinations of logs, veneer bolts and pulpwood. For example, the plantations spaced 14 by 14 feet produced more than 200 trees per acre in 5 years with a mean d.b.h. of about 6 inches. In another 2 or 3 years at least 100 of these could be removed in pulpwood thinning, leaving the remainder of logs or bolts. For the maximum production of wood fiber from small trees on a 5- or 6-year rotation, spacing can be as close as 5 by 5 feet. It seems apparent that trees of 6 to 8 inches d.b.h. for pulpwood could be produced in 7 or 8 years with an initial growing space of 60 to 80 square feet per tree.

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